200 Ohm Chopper December 20012 Update

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Project X Meeting, 12/4/2012

Topics

3D model and wound helix comparison

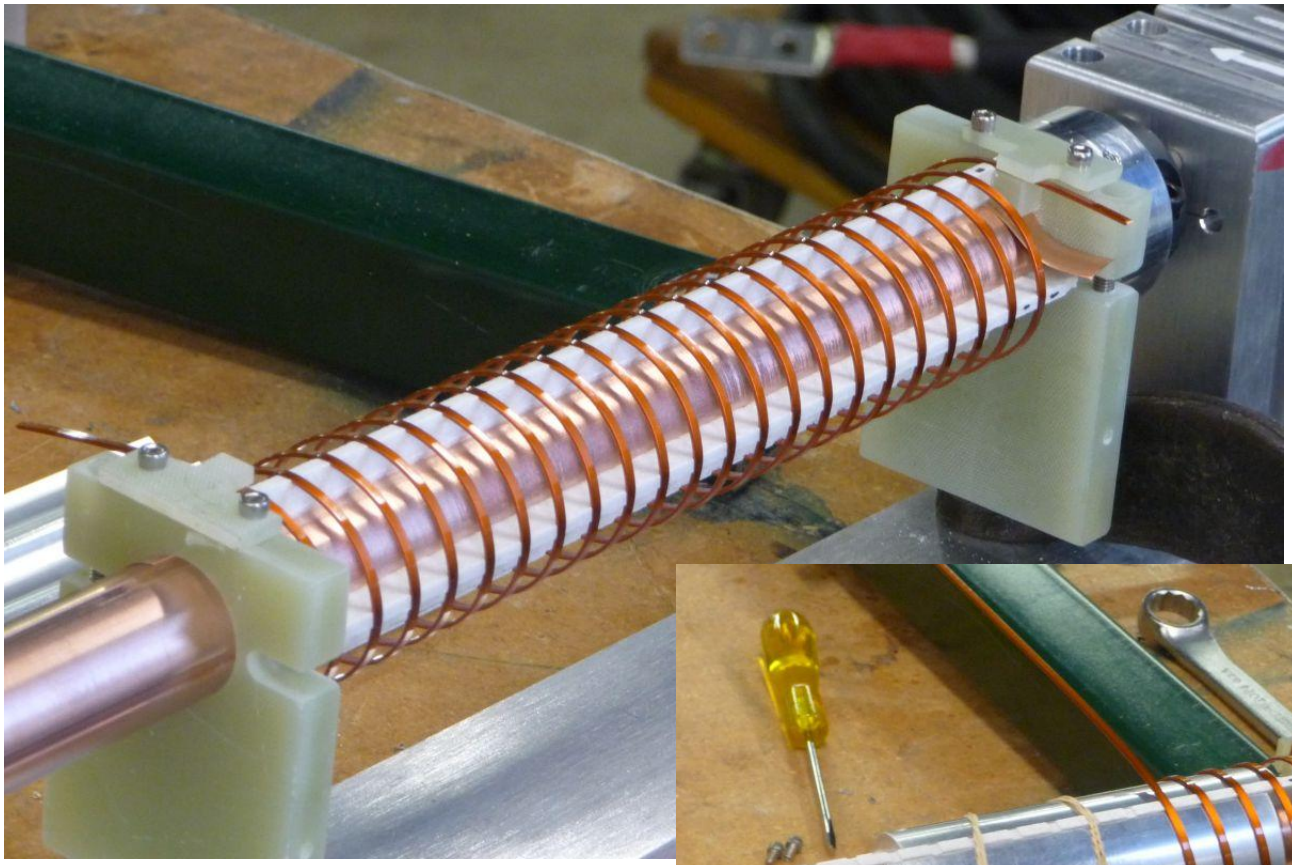
Bipolar switch development

Examined damping helix dispersion

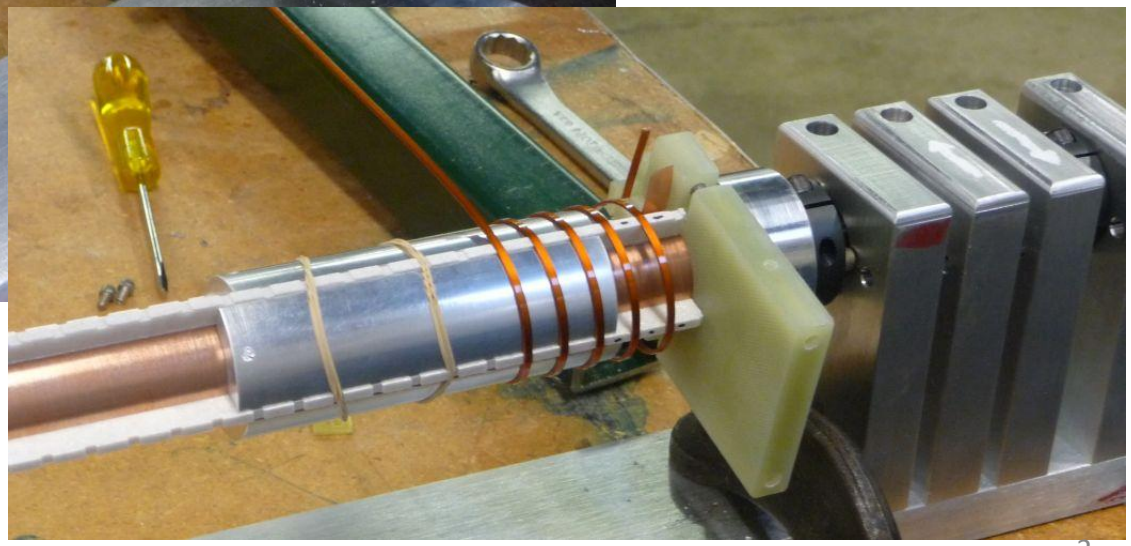
Effort since April 2012

- Work with M. Hassan (Tech. Div.) to 3D model helix having proper delay and 200 Ohm impedance
- Complete the design of a 200 Ohm system
  - Priority went to designing a bipolar driver
    - Shift away from concentrating on 500 V single-switch
    - Secondary priority is to pursue output voltages beyond 100 V
  - Four PCBs are designed

Helix in the winding fixture

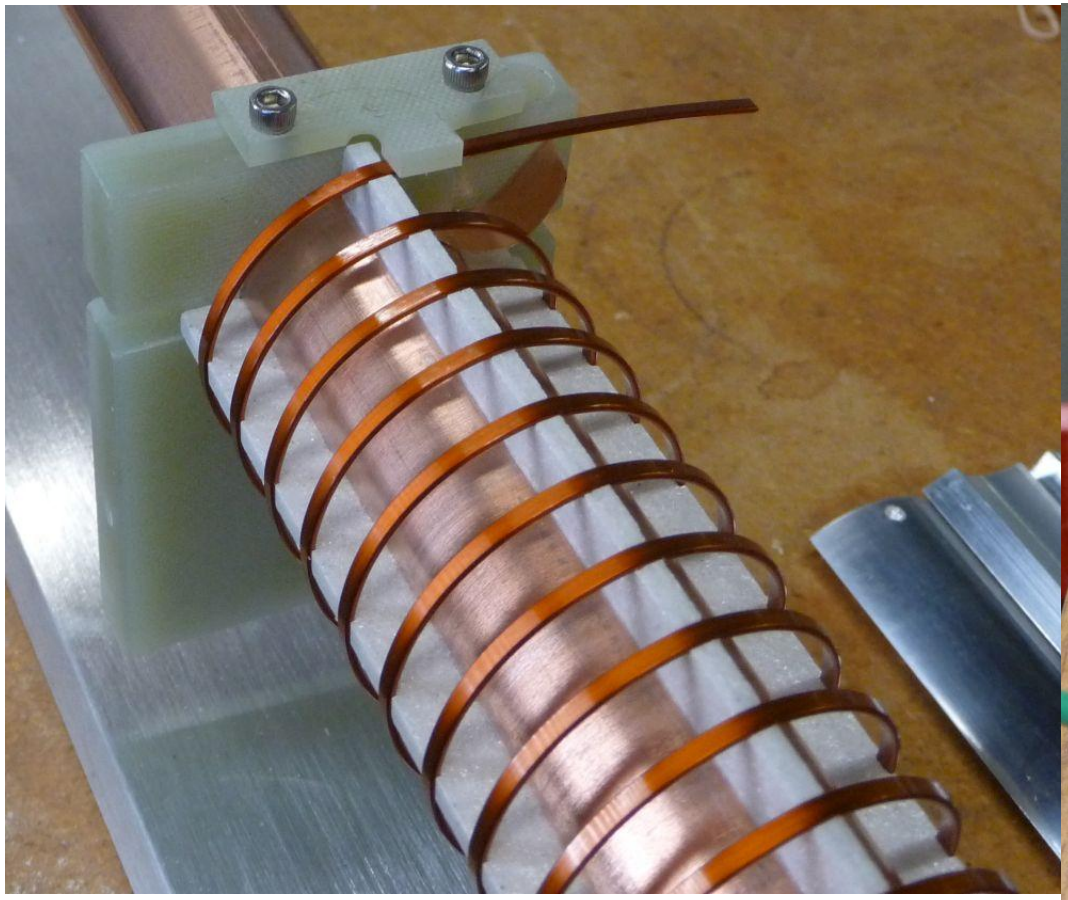


22 Turn helix wound to verify 3D modeling

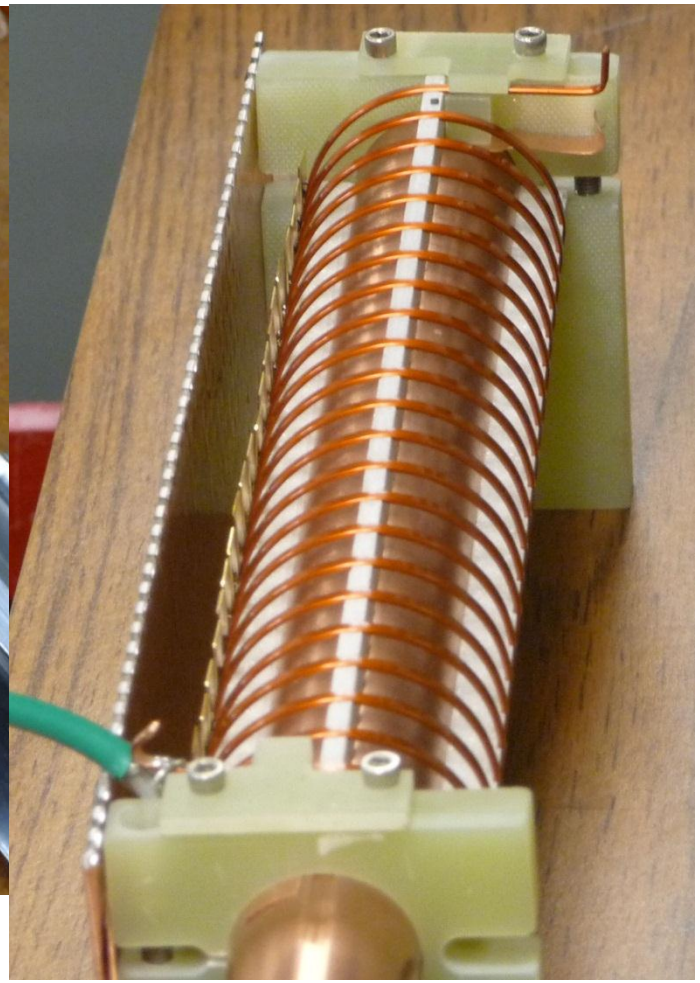


¼ m Helix

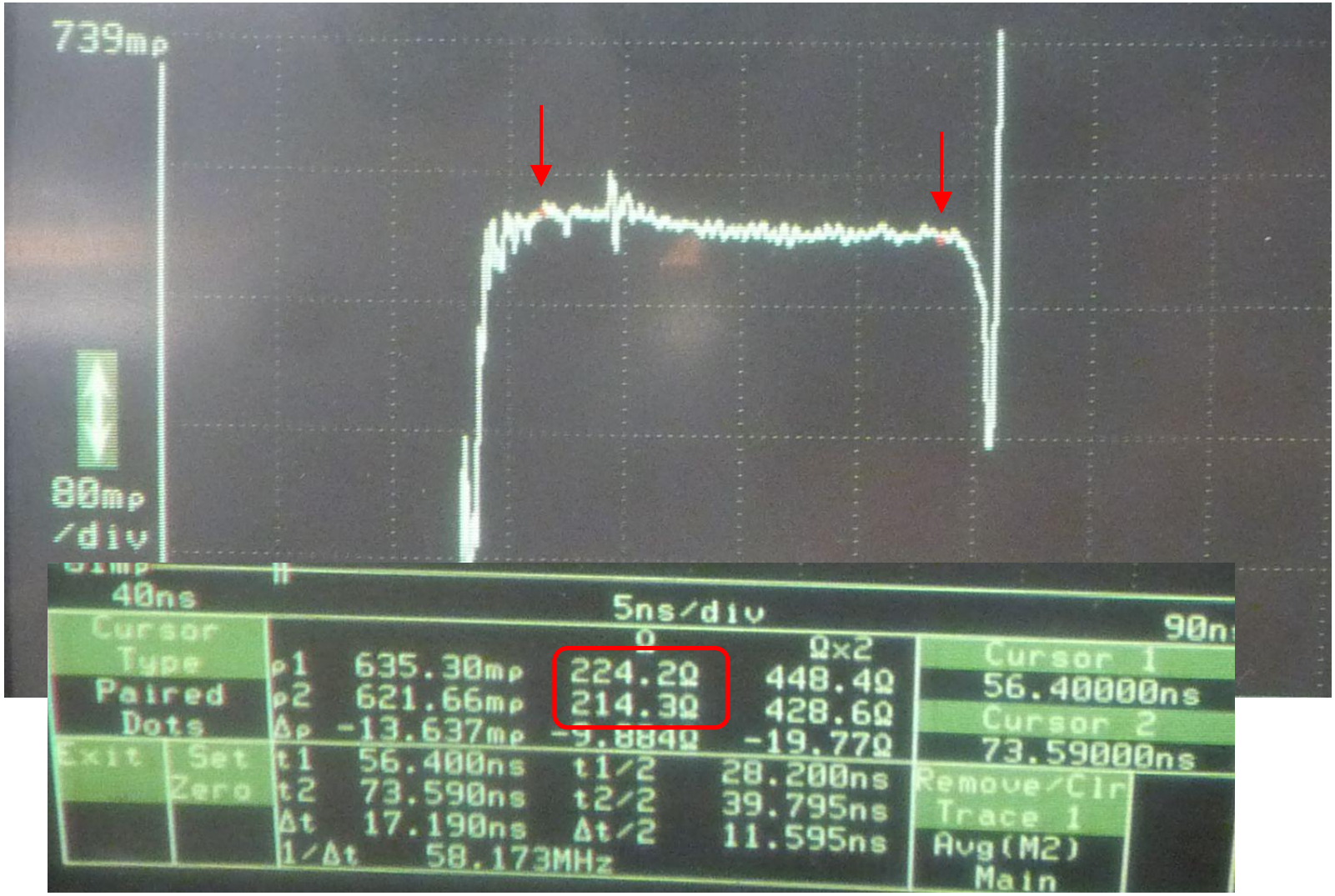
Helix only



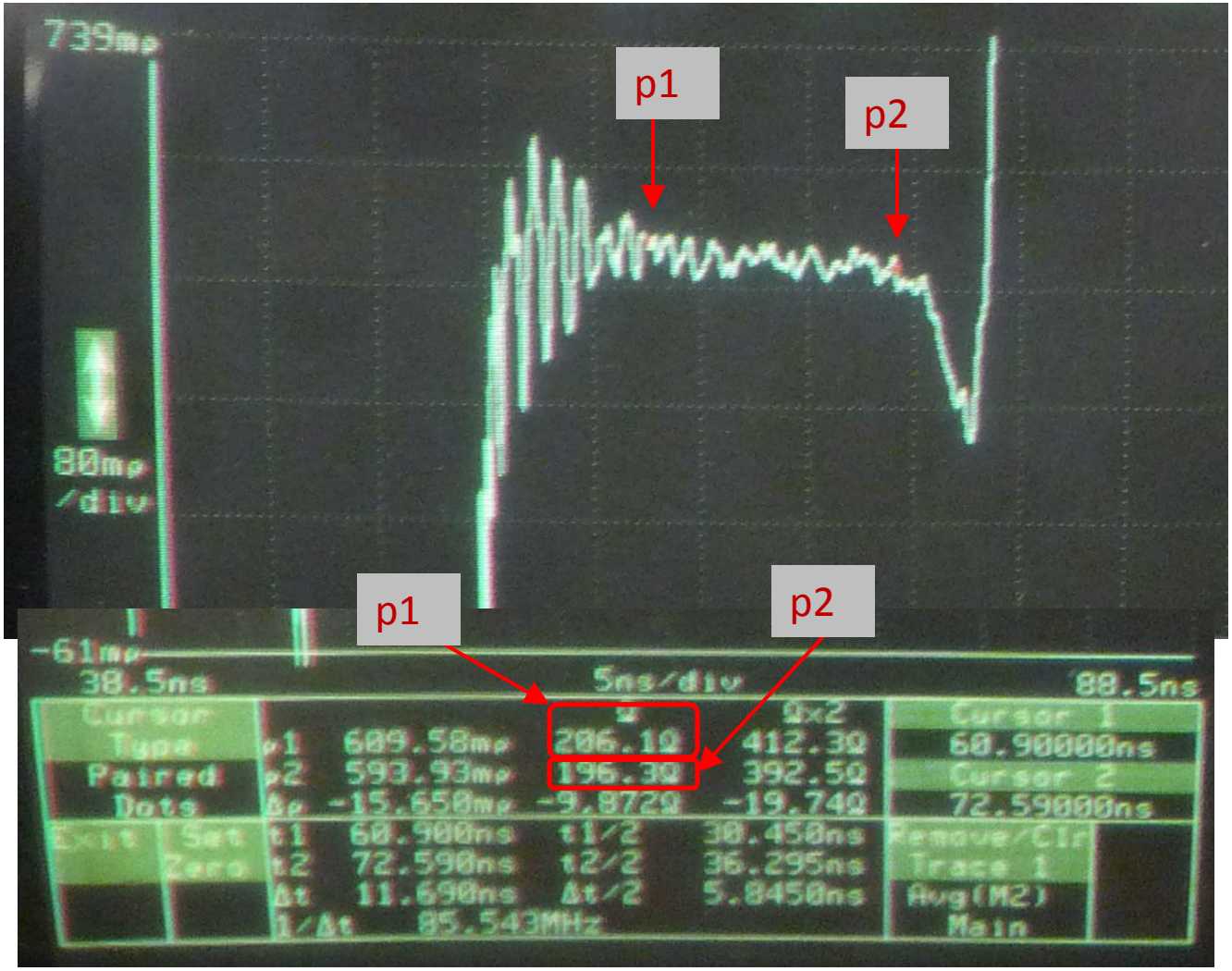
Electrodes and 0V plane attached



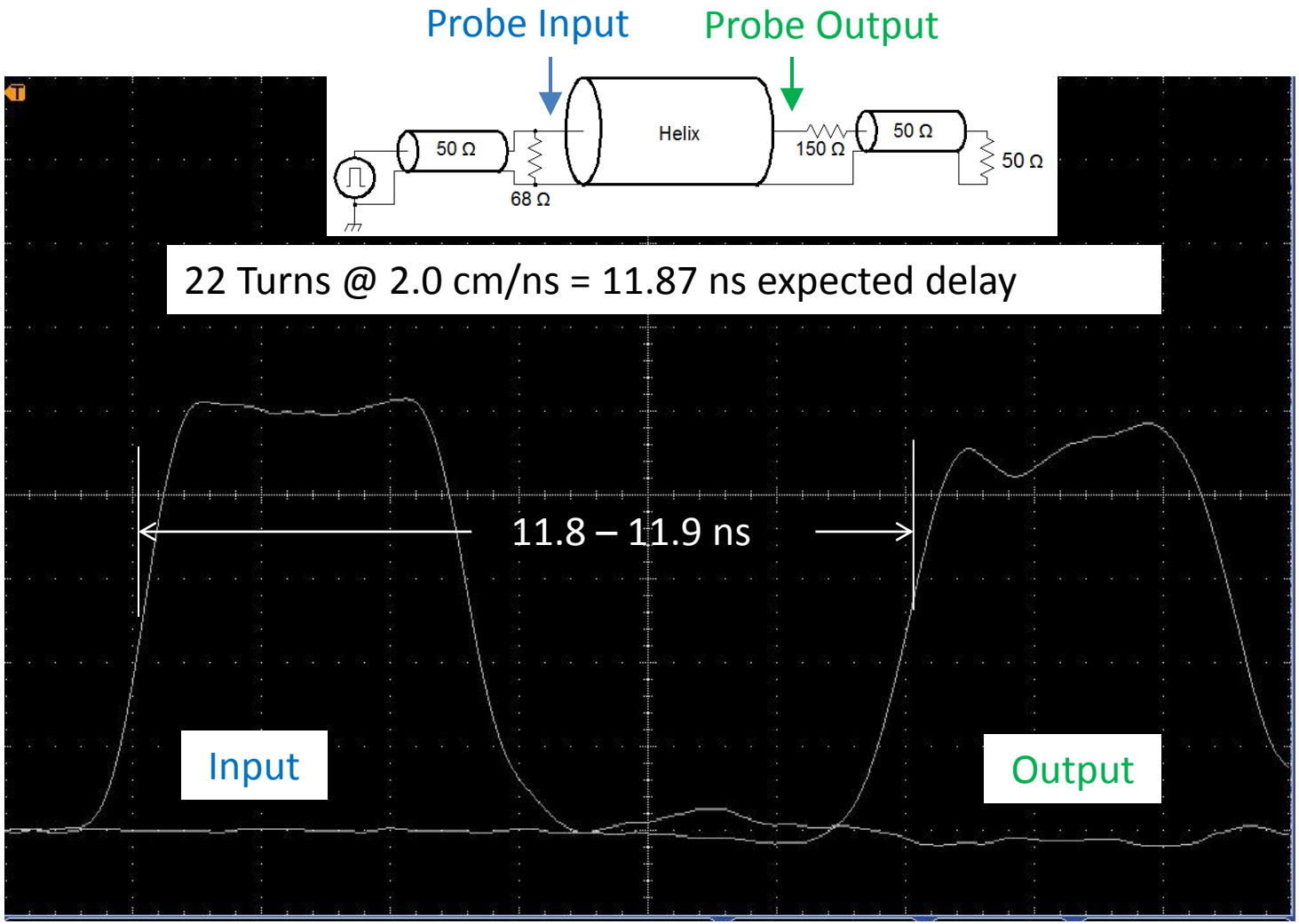
Helix-only impedance TDR measurement



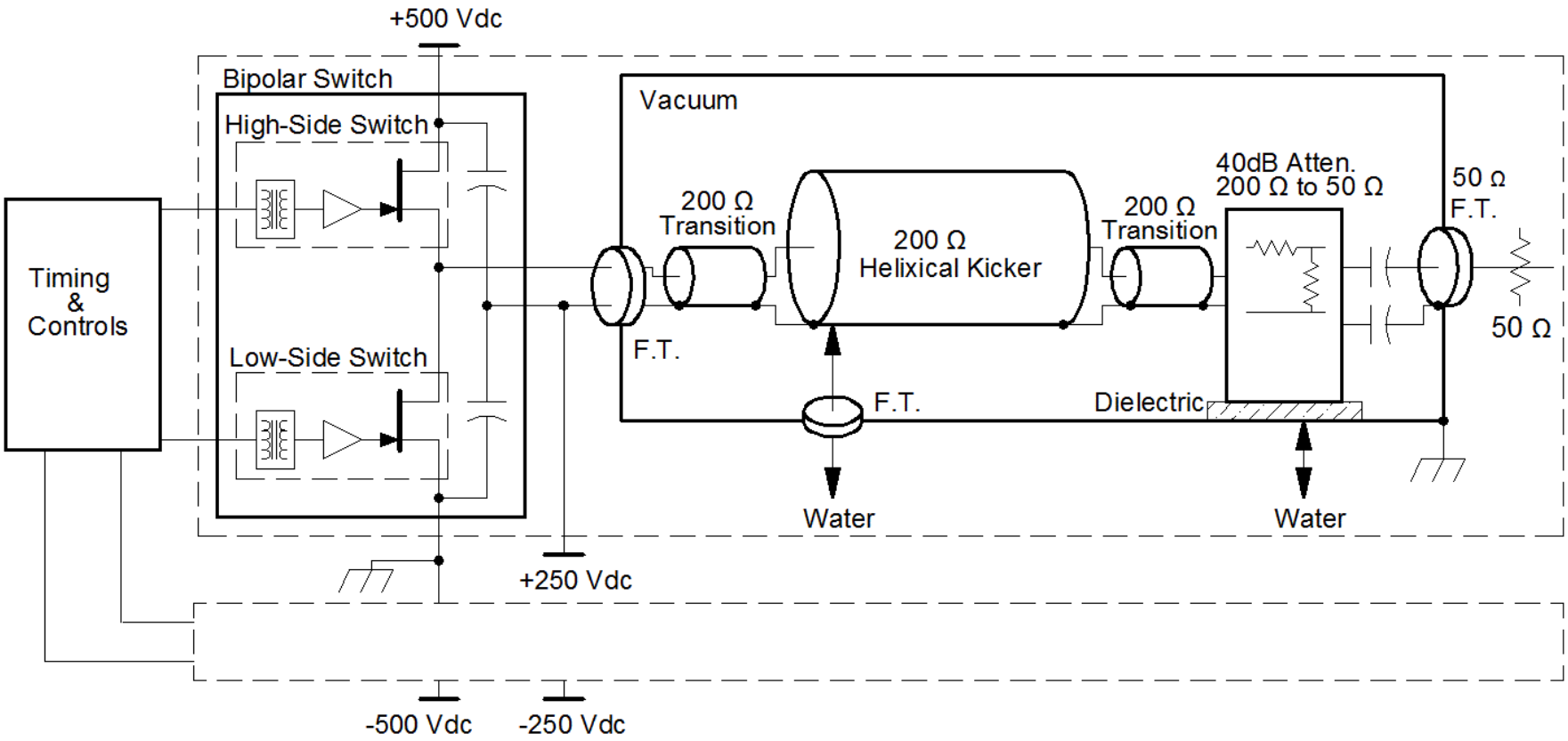
Helix impedance TDR measurement
Electrodes and 0 V plane attached



Delay measurement



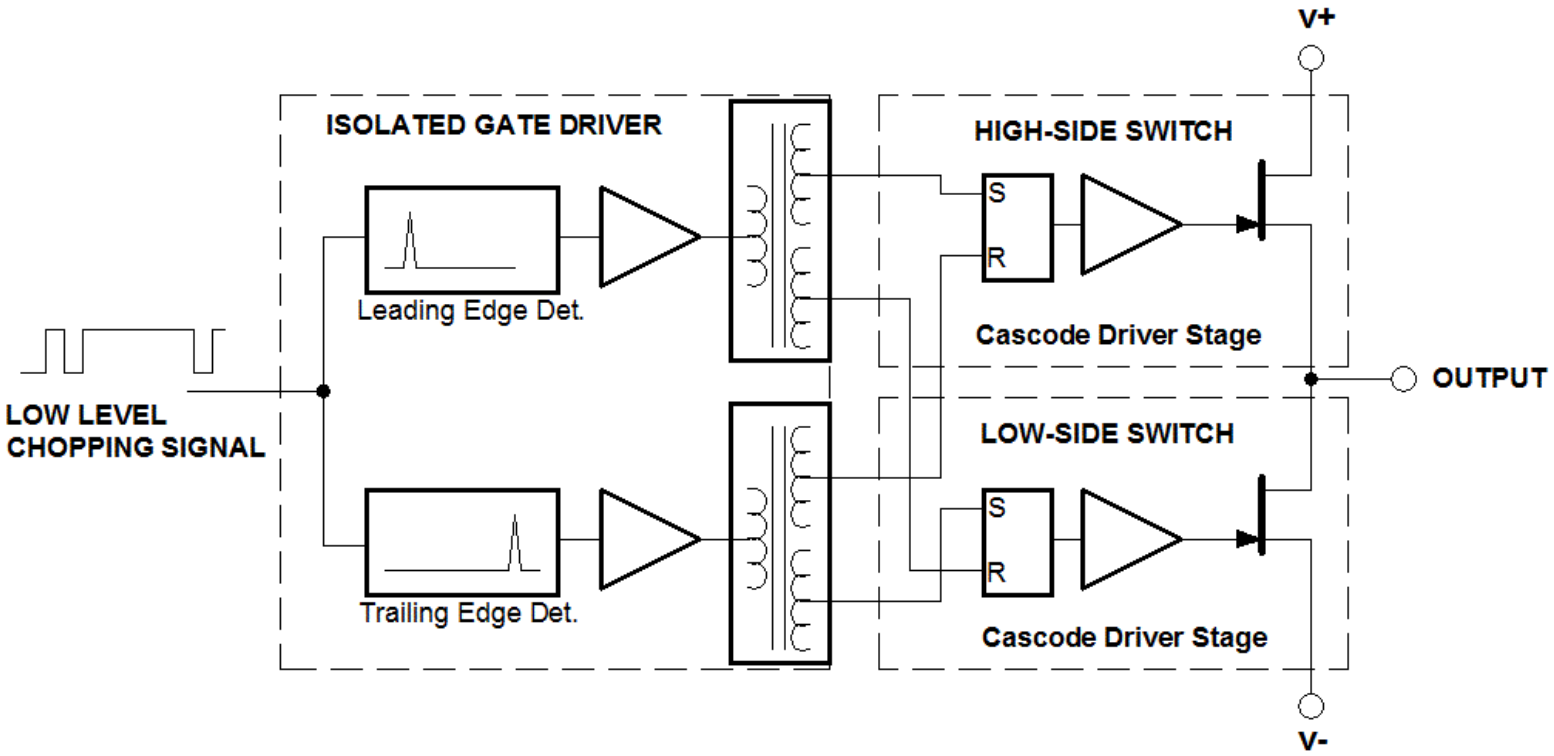
200 Ohm chopper block diagram



Bipolar driver components
(one PCB design per “component”)

- Isolated gate driver
  - One board delivers kicker timing signals to high-side and low-side switches
- Cascode driver stage
  - One each for high-side and low-side switches
  - Capable of 100 V (assuming a *Polyfet Devices* FET)
- Cascode common gate stages
  - Added for >100 V switching
  - One added stage for every additional 100 V
- Power distribution board
  - Single 5 Vdc input powers the bipolar switch
  - VAC delivered to each cascode driver board
  - VAC delivered to each common gate board
  - DC power delivered to the isolated gate board

Bipolar switch
(with gate driver)



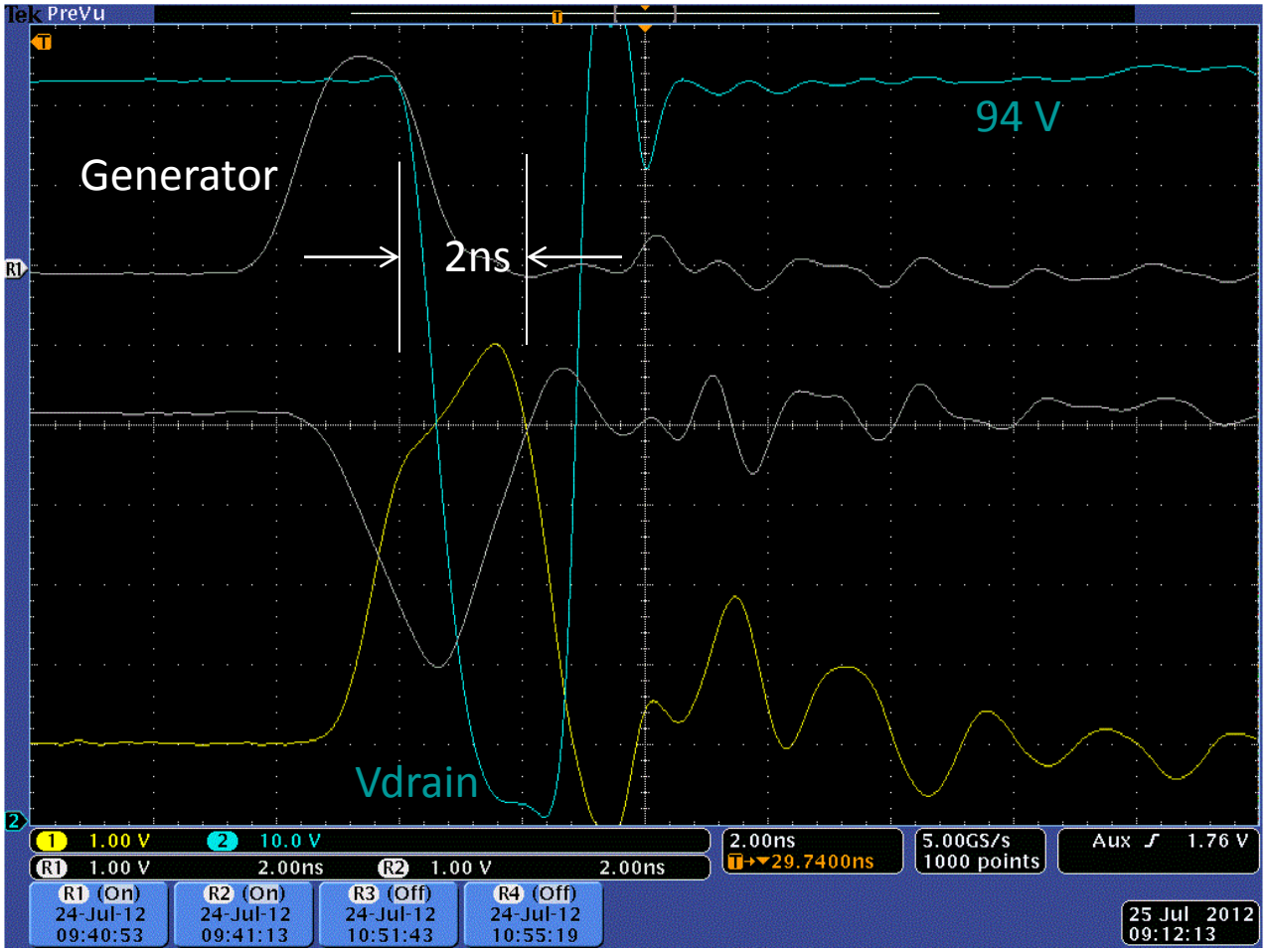
Isolated gate driver design features

- High transient immunity
  - Designed for 500 kV/μs anticipating 500 V switching
- Tight timing control
  - 80 MHz operation for chopping every other bunch
  - 74AUC1G00 logic gates used have 275 MHz clock speed
- PCBs are in-house are ready to be assembled

Cascode driver stage design features

- Predictable timing adjustability to better than 0.1 ns down to < 1.0 ns flattop
- Reliable break-before-make functionality
  - 1.2 ns dead-time guaranteed by S-R latch design
  - Provision to add more delay
- On board DC voltages are well regulated and adjustable
  - No zener diodes for voltage regulation
  - Every circuit stage has independently defined DC voltages
- Design includes all considerations for 500 V operation
  - Designed to operate with and without common gate stages attached
  - Design includes lessons learned from 1st high voltage prototype operated at 480 V

Cascode driver stage performance



Load = 2.4 A

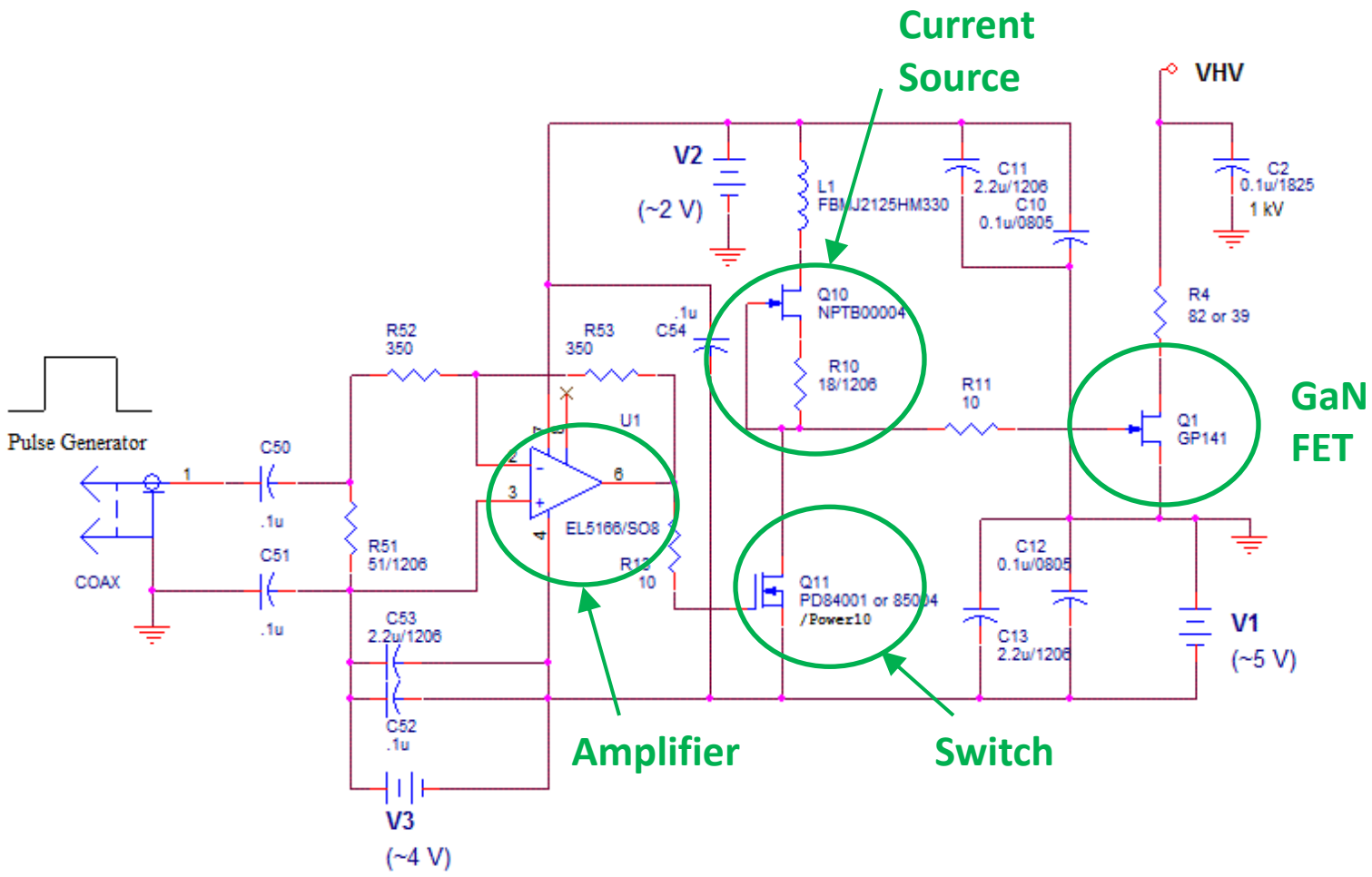
Drain voltage = 100 V

Output Rise time = 0.8 ns

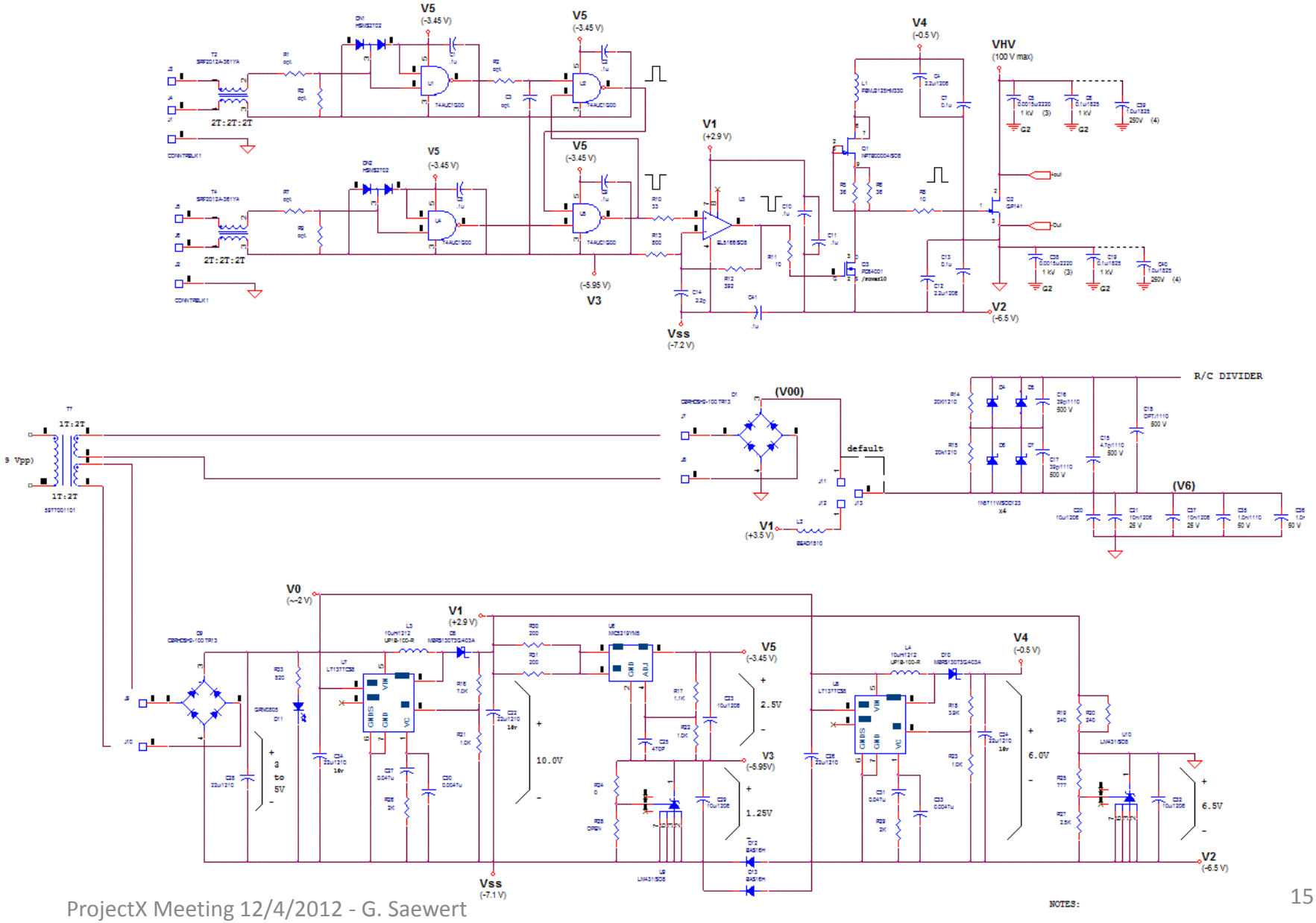
Pulse flattop = 1 ns

Pulse width is infinitely adjustable

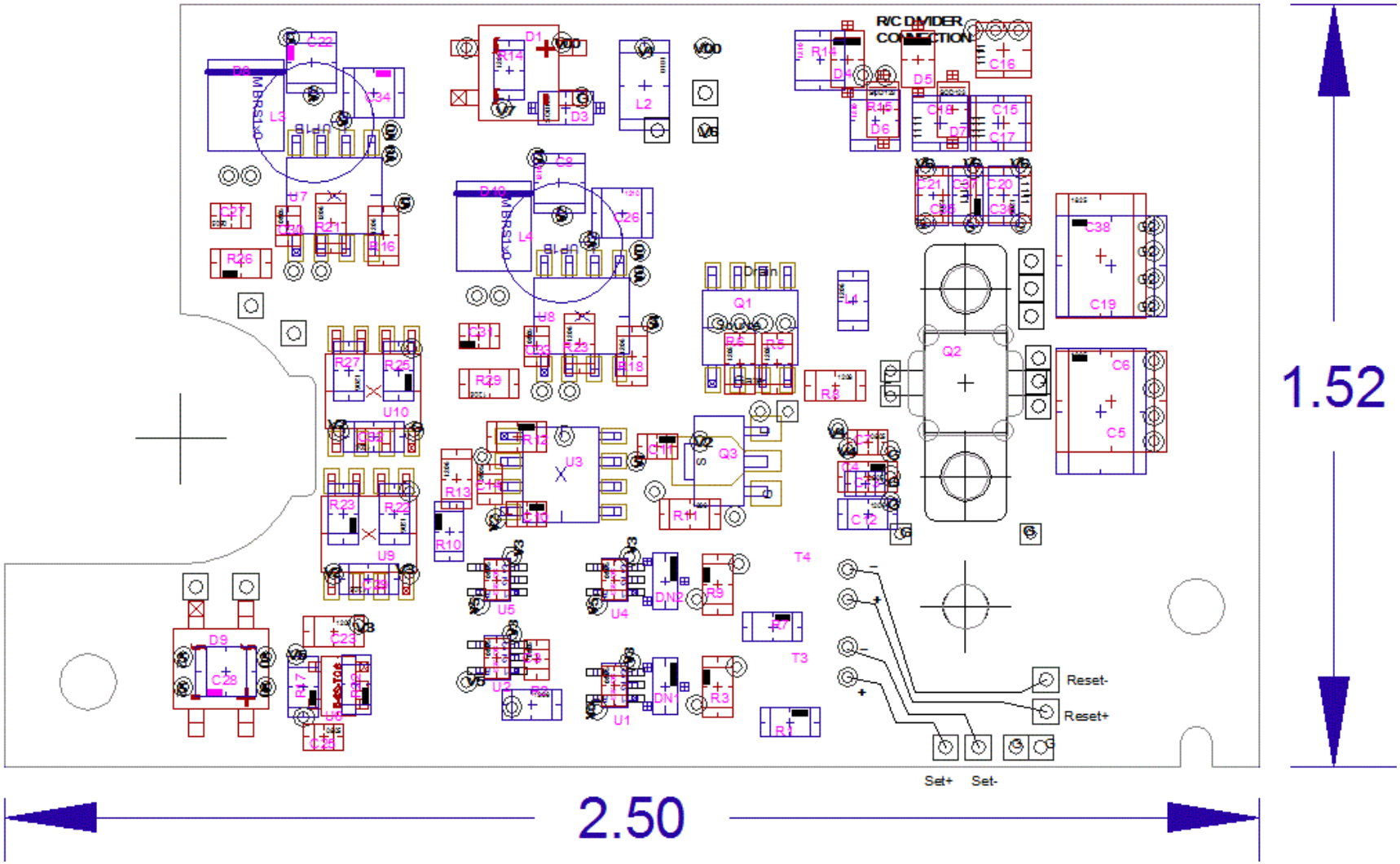
Cascode driver stage



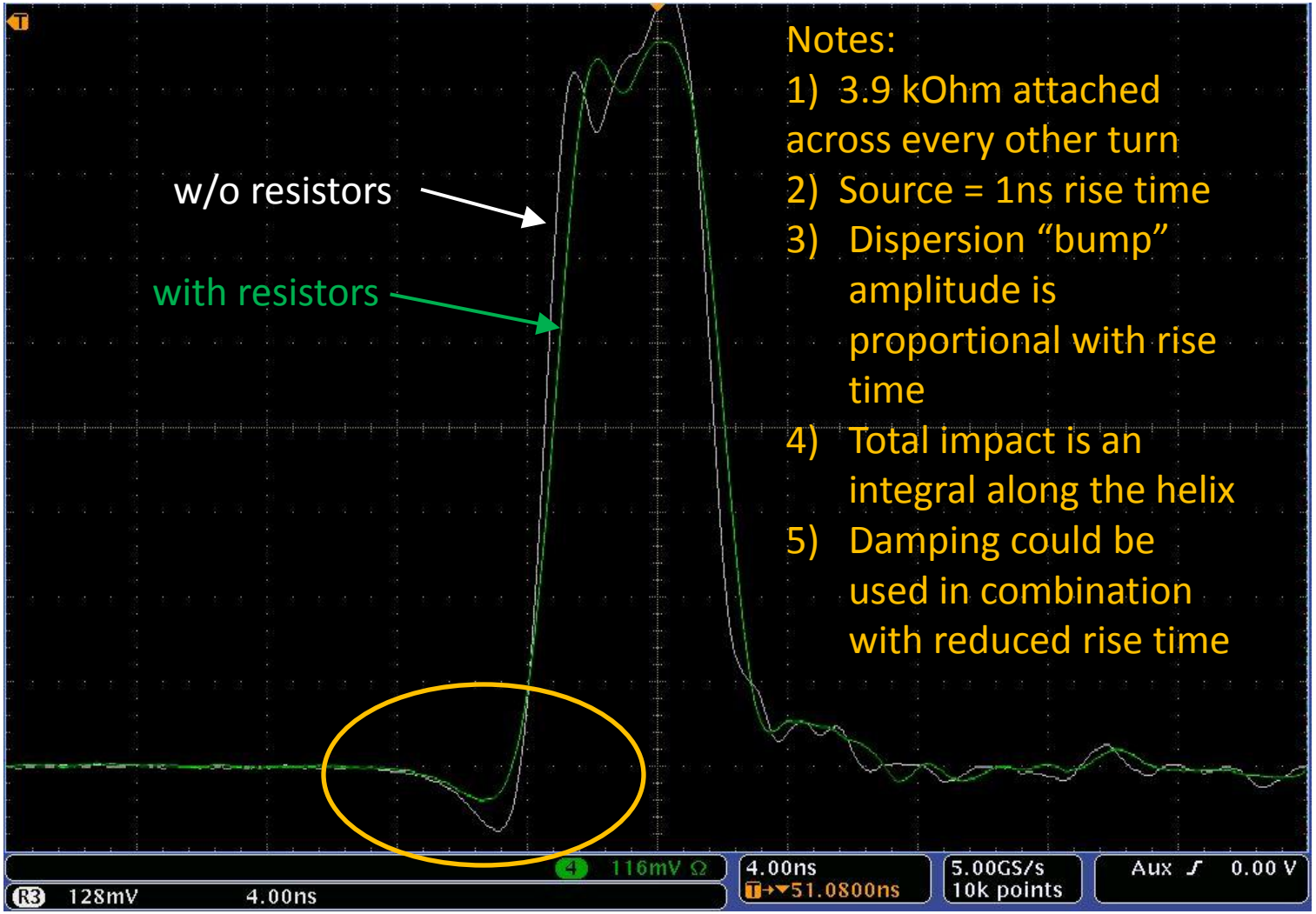
Cascode driver circuit board



Cascode driver PCB layout



Dispersion damping – D. Wolff, H. Pfeffer (test using 55 turn helix)



Summary

- A wound helix closely matches 3D model
- Helix end effects can be reduced
- Bipolar driver PCB status
  - Isolated gate driver boards just arrived
  - 3 PCBs are in the layout queue

Near future effort

- We Need mechanical engineering resources
- Complete bipolar driver
  - Use it to drive “official” helix and make power loss measurements
  - Operation beyond 100 V will be pursued
- We will better quantify 200 Ohm structure when all components arrive
  - Vacuum feed throughs are to be delivered in Dec.